

TIME VARIATIONS OF MACRO AND EXTRACTABLE STICKIES CONCENTRATIONS IN DEINKING

Donald MacNeil, Ruben Miranda, M. Concepcion Monte, Angeles Blanco, Anna Sundberg*

Department of Wood and Paper Chemistry, Åbo Akademi University, Porthaninkatu 3, 20500 Turku, Finland, and Chemical Engineering Department, Complutense University of Madrid, Avda. Complutense, s/n. 28040 Madrid, Spain

* Corresponding author. Tel. +358 2 215 4770; Fax. +358 2 215 4868
E-mail address: ansundbe@abo.fi

Abstract

The stickies content, both macrostickies and stickies extractable in a solvent, was determined for samples taken at short time intervals from deinking lines producing deinked pulp for newsprint production. The study was carried out at three mills on different continents, with each having a different source of recycled paper as raw material. The short-term variations in extractable stickies in the incoming raw material were quite extreme, with differences of 100% being seen within hours. Despite this, the final deinked pulp contained fewer sudden variations and with no correlation to the incoming stickies content. While the raw material appeared to affect the incoming stickies content, a well-optimised deinking line was able to buffer the raw material variability and the final stickies content was more dependent on the deinking process. This result was seen for the two mills examined for this phenomenon, despite a different raw material supply. Macrostickies were found to exhibit the same tendencies, although with smaller and less sudden variations. However, the variations of macrostickies and extractable stickies never correlated, even when both were measured for the same pulp fraction, thus confirming that solvent extraction is not an appropriate method for determination of macrostickies and is more a reflection of microstickies.

Introduction

Stickies are still a concern in deinking and are among the most detrimental contaminants in recovered paper recycling, affecting both the process efficiency and the quality of the final pulp. Stickies control and treatment are thus an important part of deinking line operations.¹ Assessment of the actions taken requires both measurement of the macrostickies as well as microstickies, the latter being located mostly in the fines fraction and most responsible for deposition and impaired paper machine performance.²⁻⁴ Assessment can involve either stickies determination in conjunction with stickies control trials, or mapping of stickies throughout deinking lines or at the paper machine.

With rapid changes in raw material, the varying stickies content entering the deinking line can affect interpretation of mill trials even if lasting only a few hours, and this paper's origins lie in an attempt to gauge the magnitude and speed of possible variations. In turn, mapping of stickies across a deinking line allows determination of the removal efficiency of different process stages and gives a good overview of the stickies control management in the mill.⁵

Mappings usually involve up to ten or more sampling points. A few mappings have been published for total extractable detrimental substances,⁵⁻⁷ but also specifically for either stickies^{3,8,9} or other specific detrimental components, such as fatty and resin acids¹⁰. These mappings give a picture of the concentrations of the components in question throughout the process and the removal efficiencies of various stages, which help determine the behaviour of the stickies or other detrimental substances in different stages and conditions. However, these pictures are only snapshots of the process – the situation at any one given moment in time, and do not reflect any variations in the process itself. These variations can be even more revealing, as changes in incoming raw material, changing unit operations, and changing process chemistries can play a large role in the operations of the deinking line and their effectiveness in removing detrimental substances. It can also be difficult to ascertain if these snapshots are representative of normal process conditions.

Some studies carry out the mapping two or three times and then mix the samples to determine an average value, but while this helps, it does not give an accurate picture of how the process can vary with time. Miranda and co-authors carried out two mappings but at a time interval of approximately one month, in order to compare a period of time where the mill was experiencing deposit problems to a time where the deposit problems were minimal.⁵ While this gives an indication to the extent of the differences in stickies content that could occur, it does not reveal how quickly these changes could occur. As seen in Banerjee and co-authors, conditions which could potentially lead to runnability problems, as measured by the micro-organic content, can change rapidly within hours.¹¹ It is quite reasonable that the content of stickies could experience similar variations, and comparison of processes without an idea on the variations of stickies content can lead to misleading conclusions.

The main reason for this lack of knowledge is the nature of the analysis method. While many characteristics of the process are measured online, stickies measurements are off-line, complex, and time consuming, due to the several labour-intensive sample preparation and measurement steps most methods require. One common method to measure stickies at mill scale is to determine the macrostickies, considered to be the solid and tacky contaminants larger than 150 μm . The effort required usually limits mills to selecting one or two sampling points being sampled once a day, or even more seldom.

Another method is to measure or analyse the extractable content of a sample, such as determination of the total amount soluble in an organic solvent^{5,6}, or determination of the amount of specific compounds after further analysis of the extract by FTIR^{2,12}, HPLC¹³, or PyGCMS^{8,13}. The extractable components include recycled fibre based stickies, such as styrene, acrylate, and vinyl-acetate based binders and adhesives, as well as wood pitch

components from the wood fibres themselves or process chemicals such as deinking soaps.^{3,12,13} These methods are even more time consuming, and usually require equipment or expertise not found at the mills, so samples are instead sent to external research institutes. For this reason, few measurements of this type are available for mills, which makes the scope of the work produced in this study unique.

To determine the extractable stickies content in this study, a previously published method was used, and consisted of a combination of solvent extraction with THF, followed by component separation and quantification of component groups by HPLC.¹³ THF was selected based on a previous study for comparison of solvents.¹³ While it is known that THF will not extract all components related to stickies, especially cross-linked and high molecular weight polymers, previous experiments involving the extraction of deposits from paper machines have shown that the THF-soluble fraction of a deposit shows extreme tackiness, while the non-soluble fraction exhibits no tack whatsoever. Therefore, THF will extract the majority of stickies tacky in nature and most likely to actually deposit, which are the most relevant type for a study of this nature.

This method presents the advantage of being able to more accurately determine the stickies content – the components originating from adhesives or binders in recycled fibre – without interference from other soluble components such as wood extractives. Other methods for stickies determination exist. However, many, including microscopic analysis, are even more time-consuming and subjective. One main advantage of chemical analysis over optical analysis is the ability to distinguish the components based on their chemical nature as opposed to size or shape. Many stickies are too small to be seen, and even visible ones can be hidden or missed due to their attachment onto and inside the complex fibre and inorganic particle matrix found in most pulp samples. Despite this, most mills employ a relatively rapid optical stickies determination method using a common computer scanner and specialized software. However, because there is no microscopy involved, the stickies determined are only the relatively large ones, generally greater than 150µm, and are thus considered to be macrostickies. For this reason, macrostickies determinations were carried out as well, according to mill standard methods.

Both methods, macrostickies and extractable stickies analyses, have been demonstrated as being important and complementary: Blanco and co-authors have demonstrated that an integrated approach is necessary for the full characterisation of stickies,⁷ since different methods give different information. Determination of macrostickies allows us to monitor the visible contaminants that could lead to decreased product quality¹⁴ while determination of the extractable stickies gives information about potential destabilisation of microstickies and dissolved and colloidal material. For this reason, both analysis methods were applied to the same samples when possible.

To investigate the variations with time, samples were taken at two mills at an interval of only a few hours for several days in a row. When many samples across a short time-span are analysed, it is revealed how quickly variations in stickies concentrations can occur. At the third mill, daily samples were taken for approximately one month to see the variations that could occur over a longer term. All three mills used a furnish of 100% recycled fibre, using different proportions of old newsprint (ONP) and old magazines (OMG) for

newsprint production. However, it should be noted that, despite the fact that all three mills use a fairly similar proportion of ONP:OMG, the actual raw material could vary more because of the fact that each mill receives its recycled paper from different sources. Not only would the original paper production lead to differences in the recycled paper, such as the stickies content, but the different collection programs, including sorting, storage, and transportation time, lead to different qualities of recycled paper. This can not only affect the stickies content but, more importantly, the deinking line operations required to remove the ink, the primary purpose of the deinking line. This, in turn, will affect the stickies removal from the paper and therefore the amount of stickies material in the water systems. In general, however, OMG would be expected to lead to a higher stickies content in the water systems. This is due not only to the presence of binders in the coating of light-weight-coated (LWC) papers, which make up a significant portion of OMG mixtures, but also partly due to stickies being more easily detached from the coating, as opposed to the more difficult detachment of stickies directly from the fibers and fiber networks. Stickies also originate from various glues, labels, and glued-in inserts used in magazines. The raw material types and source locations are listed in Table 1, along with other pertinent details.

Table 1. Basic information for mills surveyed and samples taken. ONP=old newsprint; OMG=old magazines; Reduced alkaline refers to either little or no caustic added to pulper.

Mill	Location	Paper supply	Furnish ONP:OMG	Pulping chemistry	Flotation collector	Sampling points	Stickies measurements
A	USA	USA Canada	60:40	reduced alkaline	synthetic	cleaner feed final DIP	extractable macro, extractable
B	Europe	UK Western Europe	50:50	reduced alkaline	fatty acids	screens feed screw press accept	macro, extractable extractable
C	China	China USA	50:50	alkaline	fatty acids	headbox	extractable

Because of the time and effort required to analyze such a large number of samples, the traditional mapping of approximately 10 points was decreased to either one or two: at the beginning and end of the deinking line (mills A and B) or from the headbox (mill C). The locations of these points are shown in a schematic, highly simplified for illustrative purposes, of a deinking line (Figure 1). As seen, the process is divided into three water circuits or loops, with each circuit being fairly isolated from the others in terms of water circulation and quality. The pulp flows forward to each successive loop, but the majority of the process water is circulated within each loop itself, with only a fraction (a few percent of the total water volume in each loop) being sent forward with the pulp fibers. This leads to an accumulation of primarily water-borne components in each circuit, while fiber-borne components are carried forward. The tendency for the components to accumulate means that each successive circuit is cleaner (in terms of chemical oxygen demand, anionic trash, etc.) than the previous. With a large volume of water in comparison to the volumes entering and exiting, each circuit could be regarded as a separate continuous stirred-tank reactor

(CSTR). In this study, however, sampling points are taken at the beginning of loop 1 and at the end of loop 2. The whole deinking line is therefore considered to be one CSTR. This is in accordance with how the issue has sometimes been approached in the literature.^{15,16} During regular operation, the residence time of fibers through each circuit would be less than 1 h and even less than 2 h for all three loops. However, because of the various dewatering stages and recirculation of water, the mean residence time of stickies, especially microstickies, would be higher.

In addition to the water circulated within each loop, process water is circulated countercurrent to the pulp flow, as is also seen in Figure 1. The most important recirculation of process water when examining these results from this study is the paper machine (PM) recirculation water, which, although cleaned, contains an accumulation of water-borne components, such as microstickies. This obviously affects the stickies content of the final deinked pulp at the storage tower (final DIP).

Materials and Methods

Macrostickies

Macrostickies were measured by first screening the samples according to TAPPI 275 sp98. Samples were diluted to 1% for screening through a Somerville screen (150 μm) and the screen rejects removed by pressurized water. The water/rejects sample from the previous step was diluted and filtered through a black wet-strength filter by a Rapid Köthen sheet former. The filter was dried and heated in a press while in contact with a coated paper. The tacky material stuck to the coating during the pressing, and upon removal of the coated paper, the tacky particles were colored white against the black background of the filter paper. Particles not strongly attached to the filter were washed off with water (10 L/min at 1 bar of pressure). The filter was dried and analyzed according to INGEDE Method 4 99-12 using an Epson Expression 1680 Pro with SENTINEL Paper Scan software at 400 dpi resolution and a contrast of 88%. The results were given by the software as millimeters squared, and the macrostickies concentration was given as millimeters squared per kilogram of dry pulp.

Total extractable stickies

Samples were first filtered through standard paper filters used for making brightness pads in the mill laboratory. Extractable stickies were analyzed by extracting the air-dried filters in an Accelerated Solvent Extractor 200 (2 \times 5 min cycles, 200 psi) supplied by Dionex using THF as the solvent. The solvent was collected and an aliquot evaporated to 1 mL and injected into an HPLC system, consisting of a size-exclusion column (Jordi 550A) and an evaporating solvent light scattering detector (Sedex 80, nebulizer temperature) 40 °C), with an eluent flow of 1.0 mL/min of THF. The polymer fraction, or the extractable stickies content of the pulp, was separated by the HPLC column from the wood extractives and quantified by a known styrene calibration solution. The method is described in more detail

by MacNeil and coauthors.¹³ The standard deviation for 10 replicates was previously determined to be less than 4%.

Microstickies

Microstickies (mill B) were determined by taking the difference (in mg/g) between two analyses: analysis of the total extractable stickies (as described above) and analysis of the extractable stickies in the fiber fraction. The latter was obtained by filtering a parallel sample through a dynamic drainage jar with a 100-mesh wire (\square 150- μ m holes). The material remaining on the wire was collected and dried for extraction and analysis (as described above for the total extractable stickies). The difference between the extractable stickies in the total sample and in the fiber fraction was defined as microstickies.

Results

Variations in extractable stickies

Mill A. At Mill A, samples were taken at 2 to 8-hour intervals from the feed to the high consistency cleaner, in other words close to the beginning of the flotation line, and from the final storage silo for deinked pulp. Results for extractable stickies are shown in Figure 2. The feed to the cleaner revealed a steady increase of (extractable) stickies during the four-day trial, with an almost four-fold increase from 2 to 8 mg/g. Smaller fluctuations were seen within the period, with changes of 20-30% possible within hours. During this time, operations of the deinking line were kept as steady as possible, with no changes in pulping or flotation chemistry due to the trial underway, which indicates that variations were due to the raw material.

The data from the final pulp samples (Figure 2) showed an even larger difference in stickies, from 0.12 to 0.62 mg/g, or a five-fold increase, but the samples had smaller short-term fluctuations than the samples from the beginning of the deinking line. It appears that the deinking line is robust and is able to “absorb” variations in incoming pulp with regard to stickies.

In addition, despite taking into account the retention time of the pulp through the deinking line, no correlation in stickies content between incoming and outgoing pulp was found. However, this point is also affected by paper machine operation, as the pulp is diluted with paper machine white water, which could increase any variations in stickies concentrations depending upon the white water contents.

Because of the lack of correlation of stickies content between the beginning and end of the deinking line, the stickies removal capability of the deinking line was not constant, and itself fluctuates, from 81% to over 95% (removal rates of the deinking lines are listed in Table 2). Often deinking lines are reported in literature or reports as having a certain stickies removal rate, but it is clear that the removal rate is highly dependent on incoming

raw material, perhaps much more than previously believed. The correct comparison of different deinking lines is obviously not easily done with only a few measurements.

Mill B. The first trial from Mill B (Figure 3) covered a shorter amount of time but included sampling at slightly shorter time intervals. Two sample points were measured: both the coarse screen accept, again close to the beginning of the deinking line, and the 2nd-loop screw press accept. In this case, the screw press accept was taken instead of the final deinked pulp to help avoid interference from white water from the paper machine used as dilution water, as was the case for Mill A.

The concentration of the stickies in the incoming pulp decreased somewhat during the trial, but the fluctuations mostly stayed within almost $\pm 50\%$ of the average, with the highest value almost three times the lowest, which is similar to the results from Mill A. However, the stickies concentrations in the screw press samples were more stable, staying within $\pm 20\%$ of the average. This is in contrast to the final deinked pulp samples from Mill A, which had variations up to 150% of the average value. This could be explained by the lesser influence from dilution waters from the paper machine in Mill B, where the screw press accept pulp sample is taken before dilution from paper machine white water.

Again, there is no correlation between incoming stickies and outgoing stickies from the deinking lines, and the removal rate of stickies in the deinking line varies significantly with time (Table 2). In these trials, however, there was no attempt to keep the operation of the deinking line constant with respect to this study, and the results reflect normal operation and any possible changes that occur. This also could be a reason for a more stable stickies content in the final pulp. As published by Sarja and co-authors, the removal of ink and stickies in flotation are closely related, either through stickies attachment to the ink particles or due to similar surface properties allowing them to be removed to the same extent in flotation.⁹ Because an important factor in deinking line operations is to keep the ink content in the final pulp low and stable, changes to achieve this could also inadvertently keep the stickies content low and stable as well.

The analysis method used above measured both stickies attached to fibres or other large particles, as well as stickies free in the water phase, either colloidal or suspended, and defined as microstickies in this study. Because microstickies are most likely to be the cause for deposition and are therefore more detrimental,²⁻⁴ the microstickies were determined by measuring the stickies on the whole sample and the fibre fraction and calculating the difference (as described in more detail in Materials and Methods).

As seen in Figure 4, the re-plotted total extractable stickies content in each sample is nearly identical to the microstickies content, with microstickies making up about 90% of the total stickies for nearly every point. This is in the same range as reported before, where two different pulp samples had 86 and 97% of the stickies passing a 150 μm wire and analyzed using the same analytical method.¹⁷ As such, it seems that the majority of the variations in stickies in the process are coming from microstickies. Because microstickies are more likely more easily removed in flotation units,^{2,5,7} it seems reasonable that the flotation cells are able to remove more stickies when more are introduced to the process in the raw material.

Mill C. The trial at Mill C involved sampling of the headbox for a period of one month. During sampling days, samples were taken throughout the day and mixed at the end for one common, pooled sample to represent the average for that day. These pooled samples were analyzed for extractable stickies and plotted in Figure 5. As seen, the stickies varied three-fold across the month, including up to 100% changes on a daily basis. The location of the sample, the headbox, along with the overall length of time of the study, makes it difficult to determine the reason behind the variations, as both mill operations and raw material can play a role. The mill reported switching of recycled fibre sources during the month, so the reason is most likely a combination of the two.

Variations in macrostickies

A second trial at Mill B was carried out with samples taken from the inlet to screening every 4 h for 4 days. Both macrostickies and total extractable stickies were measured and shown in Figure 6. The macrostickies seemed to have fewer variations with only three or four exceptions, although those exceptions were quite significant in magnitude. Extractable stickies were measured as well, and had fewer variations than the previous trials, but again with a few significant exceptions. However, when looking at the two, the exceptions did not correlate with each other: i.e., there is no relationship between macrostickies and extractable stickies concentrations in the raw material.

The study was carried out again, but this time three replicates for the macrostickies were performed, in order to ensure the exceptions were not outliers due to analytical error (Figure 7). The area of the macrostickies was larger during this trial – from 3 to 4 times higher- although the extractable stickies were actually lower than the previous trial. In any case, the error bars show that the variations far exceed any error due to analysis. Again, the changes within a single operations shift at the mill could be 100% for both extractable stickies and macrostickies.

The macrostickies content at the end of a deinking line was also measured at Mill A, with samples every four hours for nearly eight days (Figure 8). Here, the macrostickies varied in amount much more than for Mill B, even though the deinking lines were thought from previous results to even out fluctuations, at least for the extractable stickies. In fact, even differences of 300% from one sample to the next, a period of several hours, could be seen. When the extractable stickies were plotted on top, it is seen that the variations are much less between any two consecutive days. However, it is seen that macrostickies leaving the deinking line, once again, do not correlate with extractable stickies. This lends credence to the complementary approach of different stickies determination methods suggested by Blanco and co-authors.⁷

In Figure 9, the macrostickies data from Figure 7 is re-plotted (columns), while the extractable stickies retained by the 150 μm wire are plotted on top (black line). If macrostickies are fully extractable in THF, the two sets of data should in theory correlate, since they are both measured on the reject of 150 μm screens. However, it is clearly seen that no such correlation exists. Since it has been seen that macrostickies are at least partially soluble in THF¹⁸, this lack of correlation is most likely due to extractable (THF-soluble)

stickies attached to fibres influencing only the extractable stickies determination, since the fibres are washed away only during the macrostickies analysis. In any case, the macrostickies content, on any fraction of pulp, cannot be determined by dissolution in THF.

Table 2. Extractable stickies removal rates across the deinking lines for Mills A and B.

Mill	First sample	Second sample	Duration of study	Min removal	Max Removal
A	cleaners inlet	final DIP	85 hrs	81%	95%
B	screens inlet	screw press accept	32 hrs	85%	95%

Conclusions

Stickies entering deinking lines are seen to fluctuate with time, with daily variances in concentration up to 100% or more as seen in two mills with deinking lines using recycled fibre for newsprint production. The reason for these fluctuations seems to be the raw material entering the mill, even if an attempt is made to keep the quality of the raw material supply constant. This is despite the fact that all three mills, while using nearly the same raw material type, have very different raw material sources: North America, Western Europe, and China.

However, despite these fluctuations in incoming raw material, the deinking lines were seemingly able to cope well and, in general, remove more stickies when more contaminated pulps were used, thus evening out the stickies concentrations in the final deinked pulp. This was possibly due to an inherent capability of the units, but it could also be due to the slight changes made in deinking line operation in response to other factors. In any case, the final deinked pulp had a much more stable concentration of stickies than the raw material. Apparently, while the stickies content entering the deinking line is dependent upon the raw material, the final stickies content is more dependent upon the operation of the deinking lines.

It is clear that more extensive measuring programs are required if representative results are to be obtained. Measuring sample points only a few times, far apart in time, will not give a representative picture of the process when considering both stickies content and stickies removal in industrial deinking lines. This fact should be considered when performance of different mills or different sampling times are compared.

It is also seen that the macrostickies content in pulps, both entering and leaving the deinking lines, have wide variations on the same scale as extractable stickies. However, there is no real correlation in concentrations between the two in this study. It appears that even if macrostickies are partially soluble in an organic solvent, extraction of pulps is not sufficient for macrostickies determination. Therefore, a complementary approach is required.

Acknowledgements

The authors wish to acknowledge financial support from the Community of Madrid for the Project PROLIPAPEL-CM (S-0505/AMB/0100), as well as technical support from Metso Paper Inc., VTT Papermaking processes (Jyväskylä), and the South China University of Technology, Laboratory of Pulp and Paper Engineering (Guangzhou).

References

- (1) Delagoutte, T. Management and control of stickies. *Prog. Pap. Recycl.* **2005**, *15*, 31.
- (2) Johansson, H.; Wikman, B.; Lindström, E.; Österberg, F. Detection and Evaluation of Micro-stickies. *Prog. Pap. Recycl.* **2003**, *12*, 775.
- (3) Delagoutte, T.; Brun, J. Drying section deposits; origin, identification and influence of the recycling processes, deinking and packaging lines comparison. *Rev. ATIP* **2005**, *59*, 17.
- (4) Sarja, T.; MacNeil, D.; Messmer, M.; Reunanen, M.; Niinimäki, J.; Analysis of stickies in deinked pulp; Part II: Distribution of stickies in deinked pulp. *Prof. Papermaking* **2006**, *1*, 15.
- (5) Miranda, R.; Blanco, A.; Negro, C.; Tijero, J. Stickies removal in a deinking line of a newsprint mill: Efficiency of the different process stages. *Cellul. Chem. Technol.* **2006**, *40*, 775.
- (6) Kolb, W.; Heusser, U. Flow diagram for disturbing substances in deinking lines. (in German). *Wochenbl. Papierfabr.* **1986**, *114*, 1.
- (7) Blanco, A.; Miranda, R.; Negro, C.; Garcia-Suarez, C.; Garcia-Prol, M.; Sanchez, A. Full characterization of stickies in a newsprint mill: the need for a complementary approach. *TAPPI J.*, **2007**, *6*, 19.
- (8) Asp, F. Detrimental substances in a deinking mill. M.Sc. Thesis (in Swedish), Abo Akademi University, Finland, 1994.
- (9) Sarja, T.; MacNeil, D.; Huber, P.; Niinimäki, J. Removal of stickies in flotation. *Prog. Pap. Recycl.* **2007**, *16*, 5.
- (10) MacNeil, D.; Holmback, A.; Lassus, A.; Hoel, H.; Roring, A.; Holmbom, B. Removal of fatty and resin acids in European deinking processes. *Prog. Pap. Recycl.* **2004**, *14*, 6.
- (11) Banerjee, S.; Yang, R.; Haynes, R.D. Aggregation of colloidal material in recycling process water. *TAPPI J.* **2009**, *8*, 19.

- (12) Miranda, R.; Balea, A.; Sanchez, E.; Carrillo, I.; Blanco A. Identification of Recalcitrant Stickies and Their Sources in Newsprint Production. *Ind. Eng. Chem. Res.* **2008**, *47*, 6239.
- (13) MacNeil, D.; Sarja, T.; Reunanen, M.; Xu, C-L.; Holmbom, B. Analysis of stickies in deinked pulp: Part I: Methods for extraction and analysis of stickies. *Prof. Papermaking* **2006**, *1*, 10.
- (14) Sithole, B.; Fillion, D. Assessment of methods for the measurement of macrostickies in recycled pulps. *Prog. Pap. Recycl.* **2008**, *17*, 16.
- (15) Miranda, R.; Blanco, A.; Negro, C. Accumulation of dissolved and colloidal material in papermaking – Application to simulation. *Chem. Eng. J.* **2009**, *148*, 365.
- (16) Mittal, A.; Iribarne, K.G.; Rajan, S.G.; Chatterjee, S.G. Buildup of dissolved solids in a paperboard mill with water closure. *Prog. Pap. Recycl.* **2006**, *15*, 19.
- (17) Sarja, T.; MacNeil, D.; Kunzel, U. Addressing the nature of stickies in deinked pulp. In *2006 TAPPI Engineering, Pulping and Environmental Conference*, Norcross, GA (United States), November 5-8, 2006; TAPPI Press; Atlanta, GA, 2006; paper 2.
- (18) Sjöström, J.; Holmbom, B. Size-exclusion chromatography of deposits in pulp and paper mills. *J. Chrom.* **1987**, *411*, 363.

LIST OF FIGURES

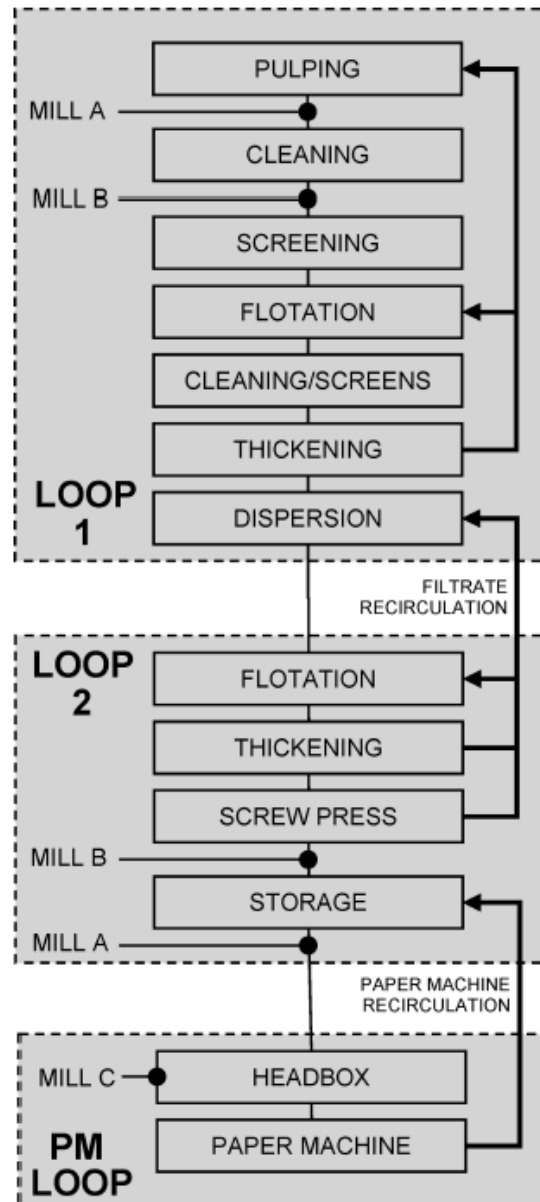


Figure 1. Schematic of a deinking line with sampling points.

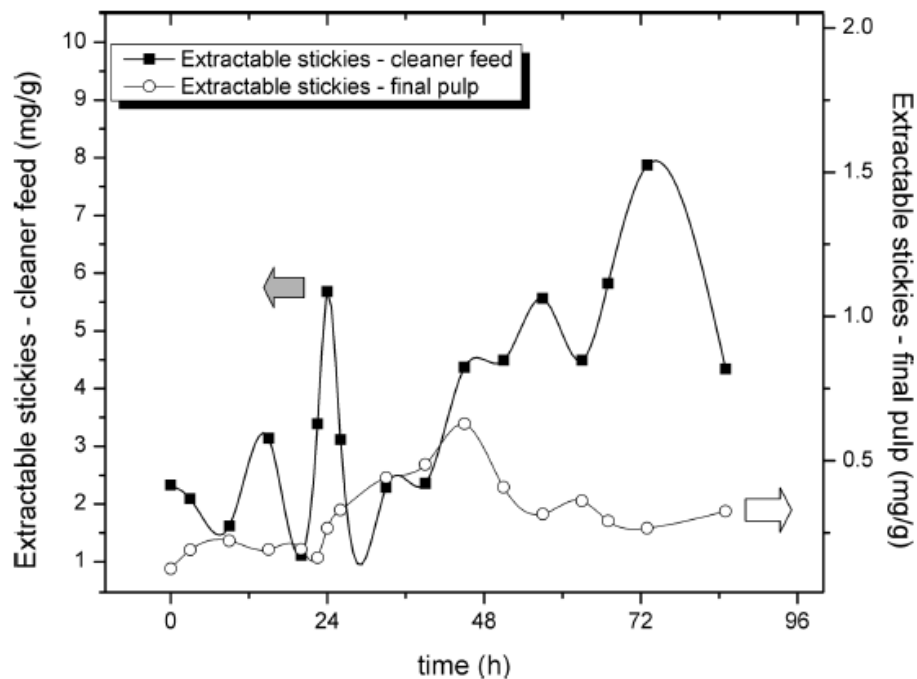


Figure 2. Extractable stickies content for the cleaner feed sample (black squares) and the final pulp sample (white circles) for mill A.

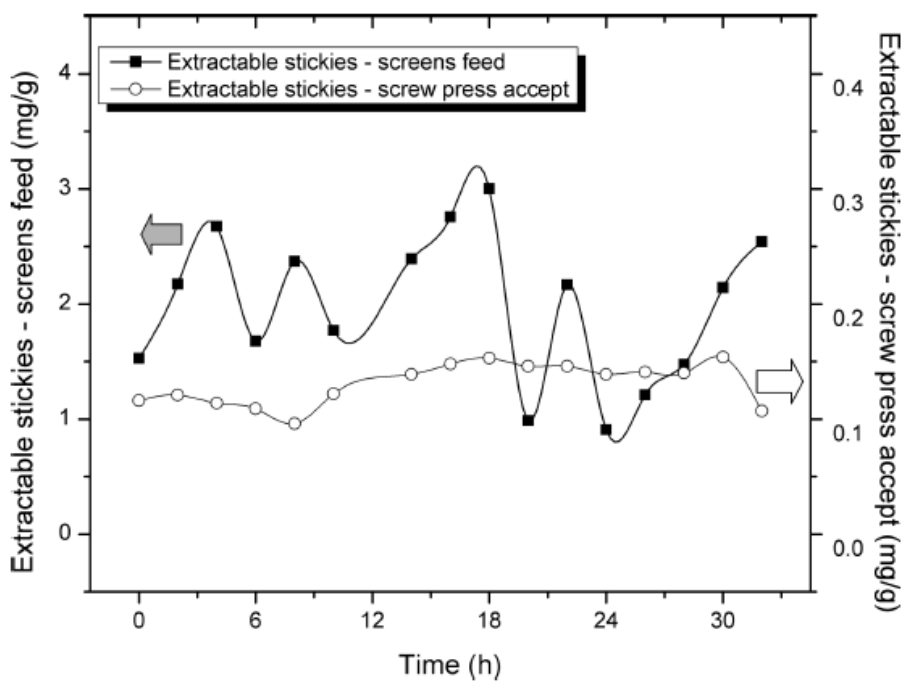


Figure 3. Extractable stickies content for the screening feed sample (black squares) and the screw press accept sample (white circles) for mill B.

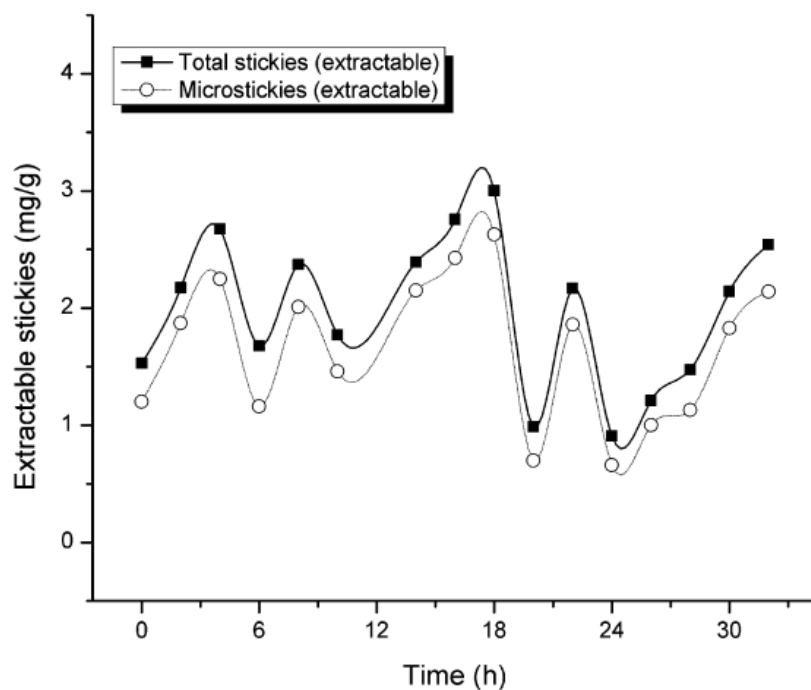


Figure 4. Total extractable stickies content (black squares) and extractable microstickies content (white circles) on the same sample (mill B screw press accept).

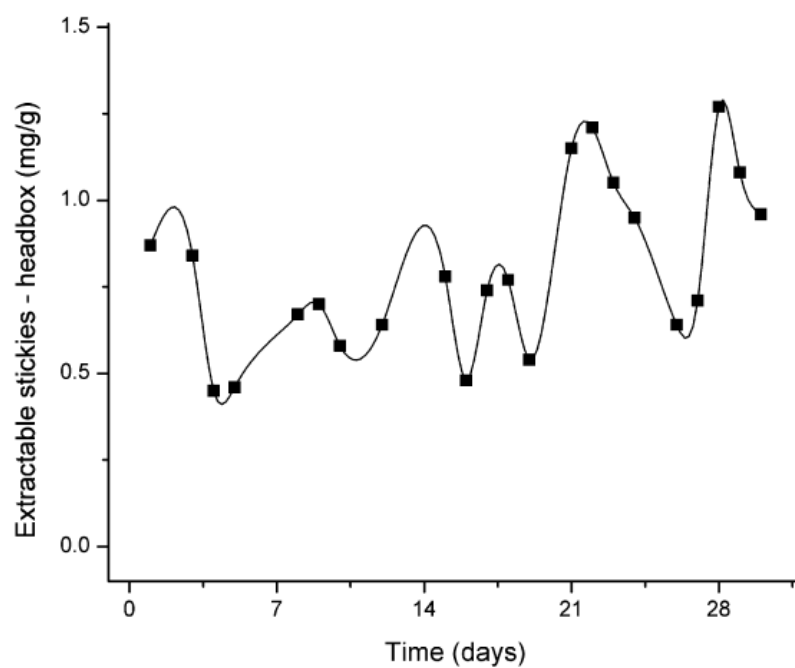


Figure 5. Extractable stickies content in headbox samples for mill C.

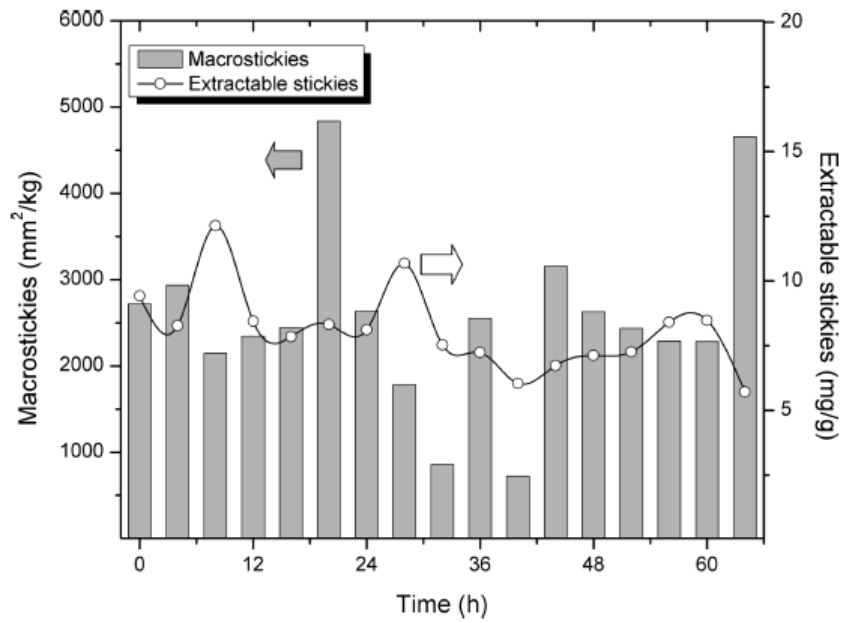


Figure 6. Macrostickies (gray column) and extractable stickies content (white circles) for mill B (screening stage inlet pulp), first trial.

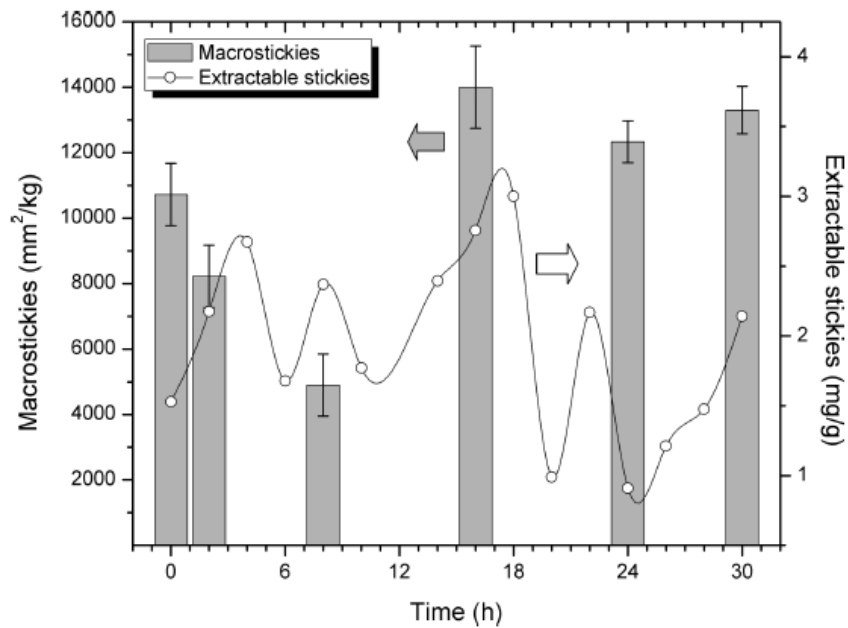


Figure 7. Macrostickies (gray columns) and extractable stickies content (white circles) for mill B (screening stage inlet pulp), second trial.

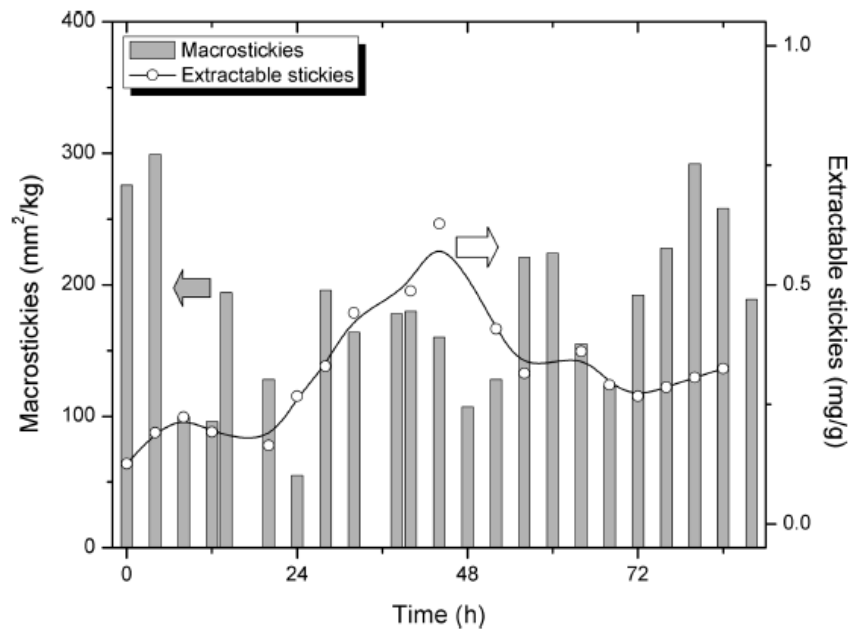


Figure 8. Macrostickies (gray columns) and extractable stickies content (white circles) for mill A (final deinked pulp).

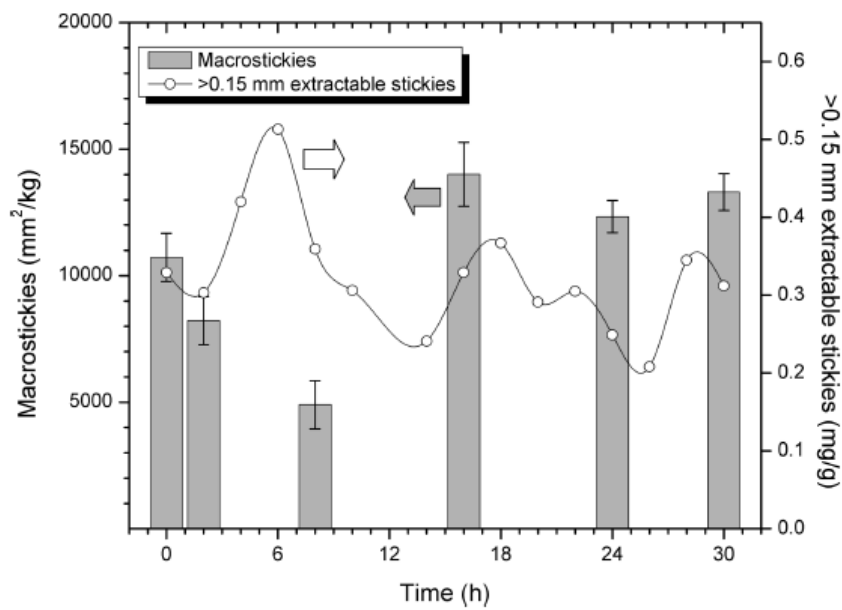


Figure 9. Macrostickies (gray columns) and extractable stickies content (white circles) on the fiber fraction (>0.15 mm) for mill B (screening stage inlet pulp).